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H4P PRE

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(56) Documents Cited

GB 2337169 A WO 99/17440 A1 WO 98/51005 A1
WO 98/12800 A1 US 5524285 A US 5404378 A

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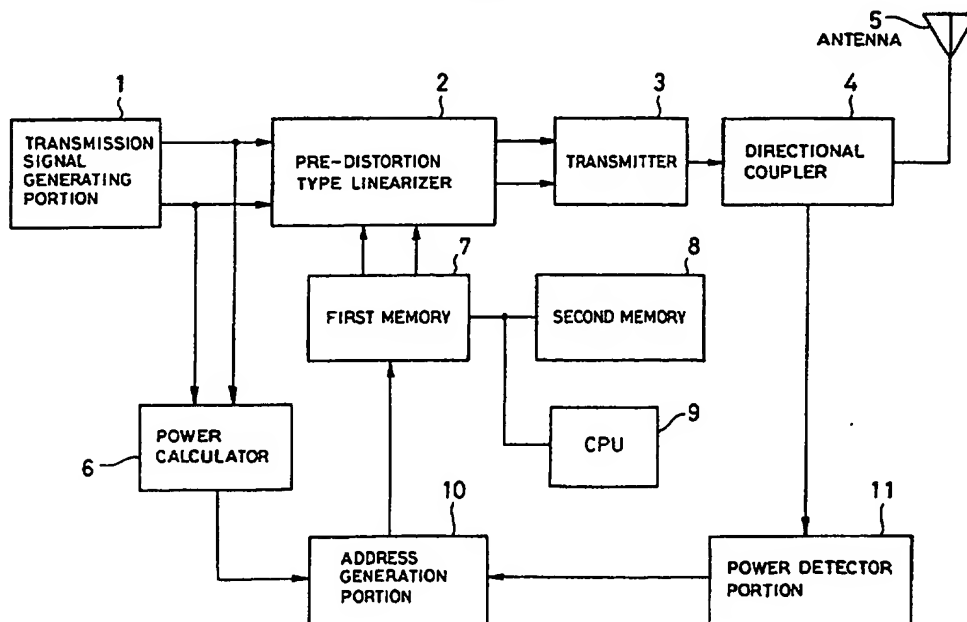
(54) Abstract Title

Transmitter pre-distortion linearizer with a memory for correction coefficients

(57) A pre-distortion linearizer 2 for correcting non linearities introduced to a signal by a transmitter 3 (modulator and amplifier) has a first memory 7 which stores tables of amplitude and phase correction data. The instantaneous power of the I and Q base band signals is calculated 6 and the power of the RF signal for transmission is also detected 11. These two power signals are fed into an address generating portion 10 which determines an address in the first memory in dependence upon them. The correction data from that address is then fed into the linearizer which applies it to the base band signal.

The system also includes a second memory 8 which stores further tables of correction data for different operating temperatures and frequencies. These may be transferred to the first memory by the CPU 9 as the temperature and frequency vary in a caching arrangement.

FIG.1



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FIG.1

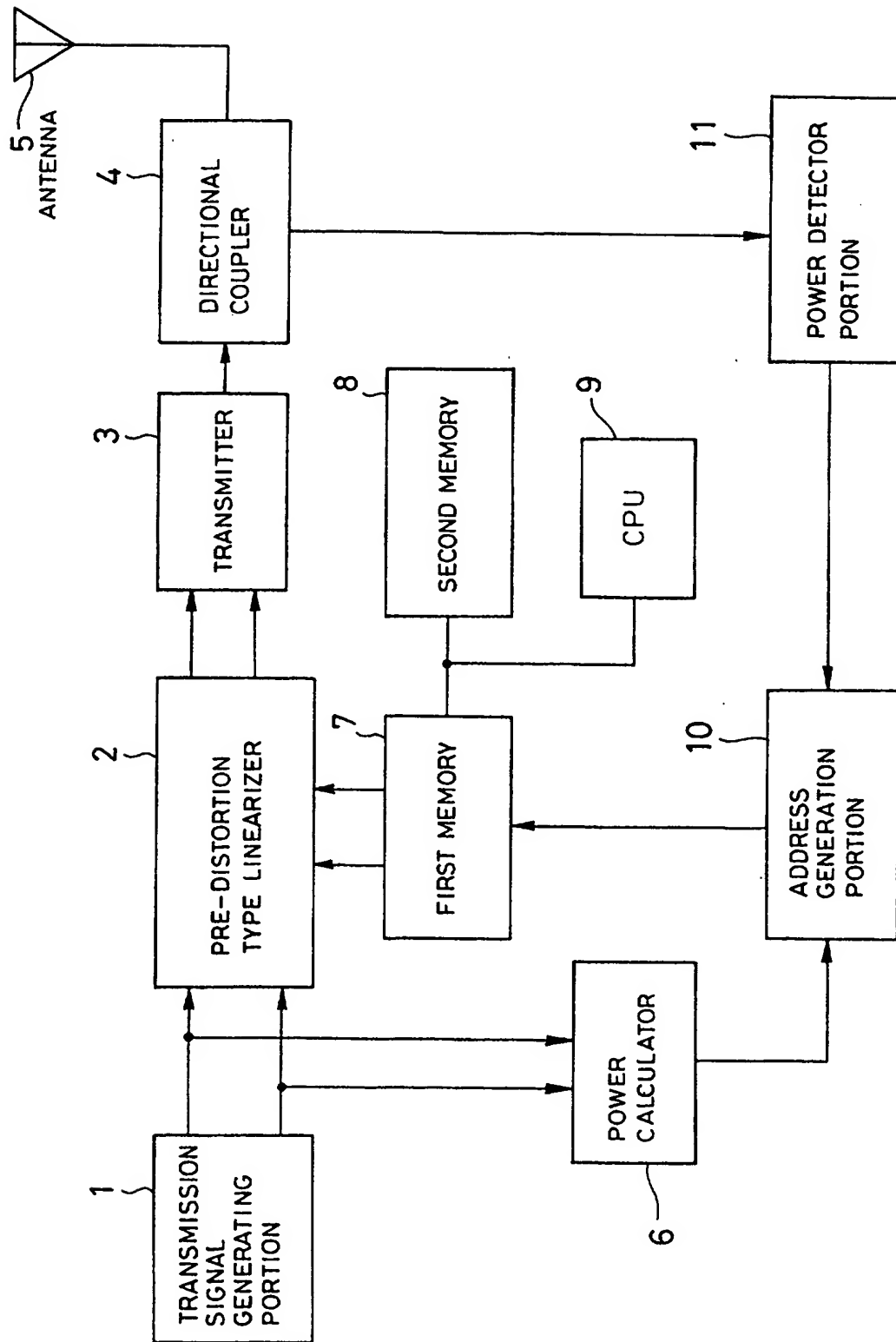


FIG. 2

(V1 + v2) LEVEL	ADDRESS
$< A_0$	0
$A_0 \leq V < A_1$	1
$A_1 \leq V < A_2$	2
$A_2 \leq V < A_3$	3
\vdots	\vdots

FIG. 3

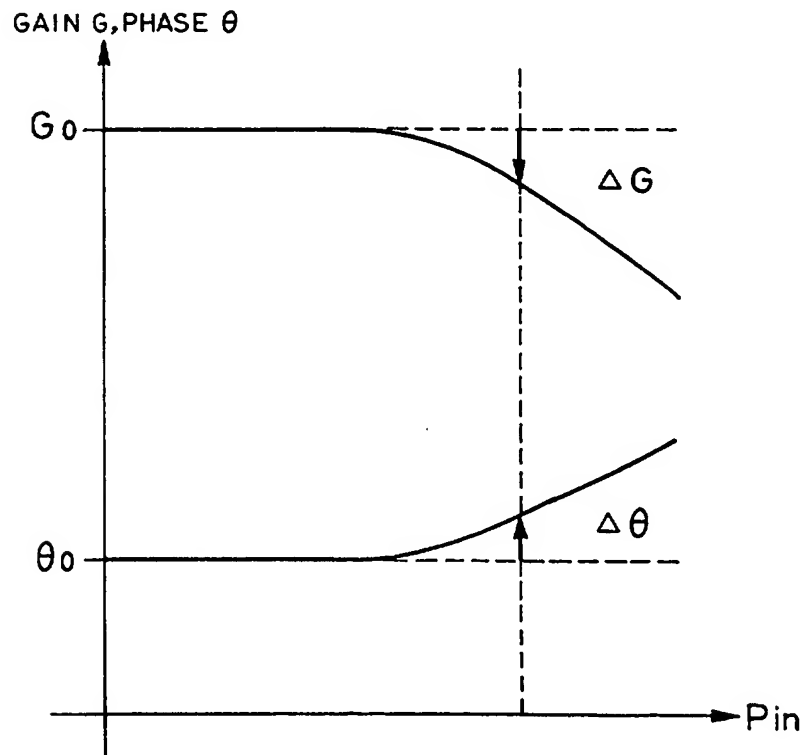
COMPENSATION DATA TABLE #1

ADDRESS	DATA	
0	$-\Delta G_{10}$	$-\Delta \theta_{10}$
1	$-\Delta G_{11}$	$-\Delta \theta_{11}$
2	$-\Delta G_{12}$	$-\Delta \theta_{12}$
3	$-\Delta G_{13}$	$-\Delta \theta_{13}$
\vdots	\vdots	\vdots

FIG.4

TEMPERATURE t/FREQUENCY f	f 0	f 1	f 2	.....
$t < t_0$	TABLE # 0	.....	.....	.....
$t_0 \leq t < t_1$	TABLE # 1	.....	.....	.....
$t_1 \leq t < t_2$	TABLE # 2	.....	.....	.....
$t_2 \leq t < t_3$	TABLE # 3	.....	.....	.....
⋮	⋮	⋮	⋮	⋮

FIG.5



GAIN AND PHASE CHARACTERISTICS OF TRANSMITTER
3 ALONE

FIG. 6

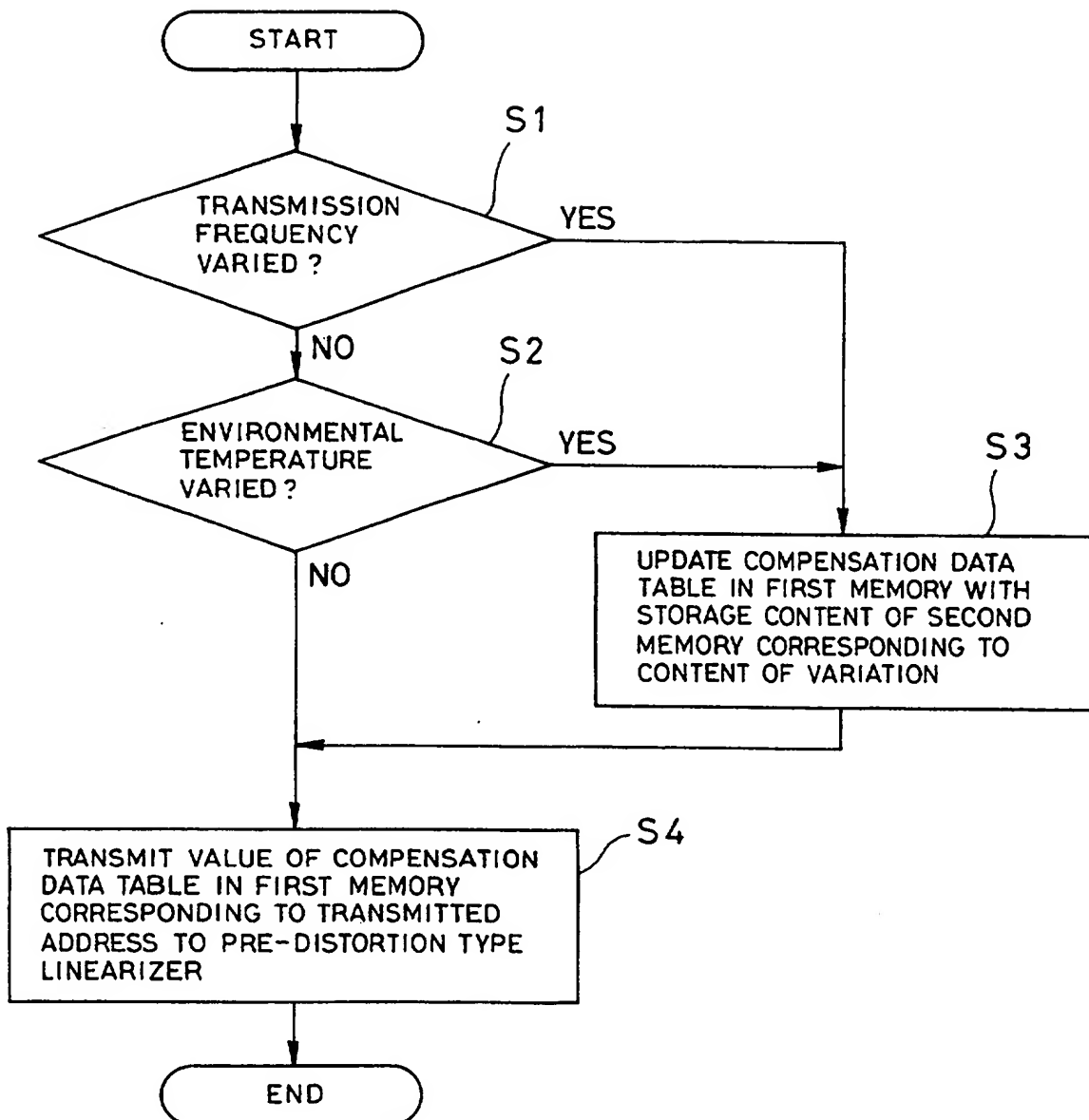
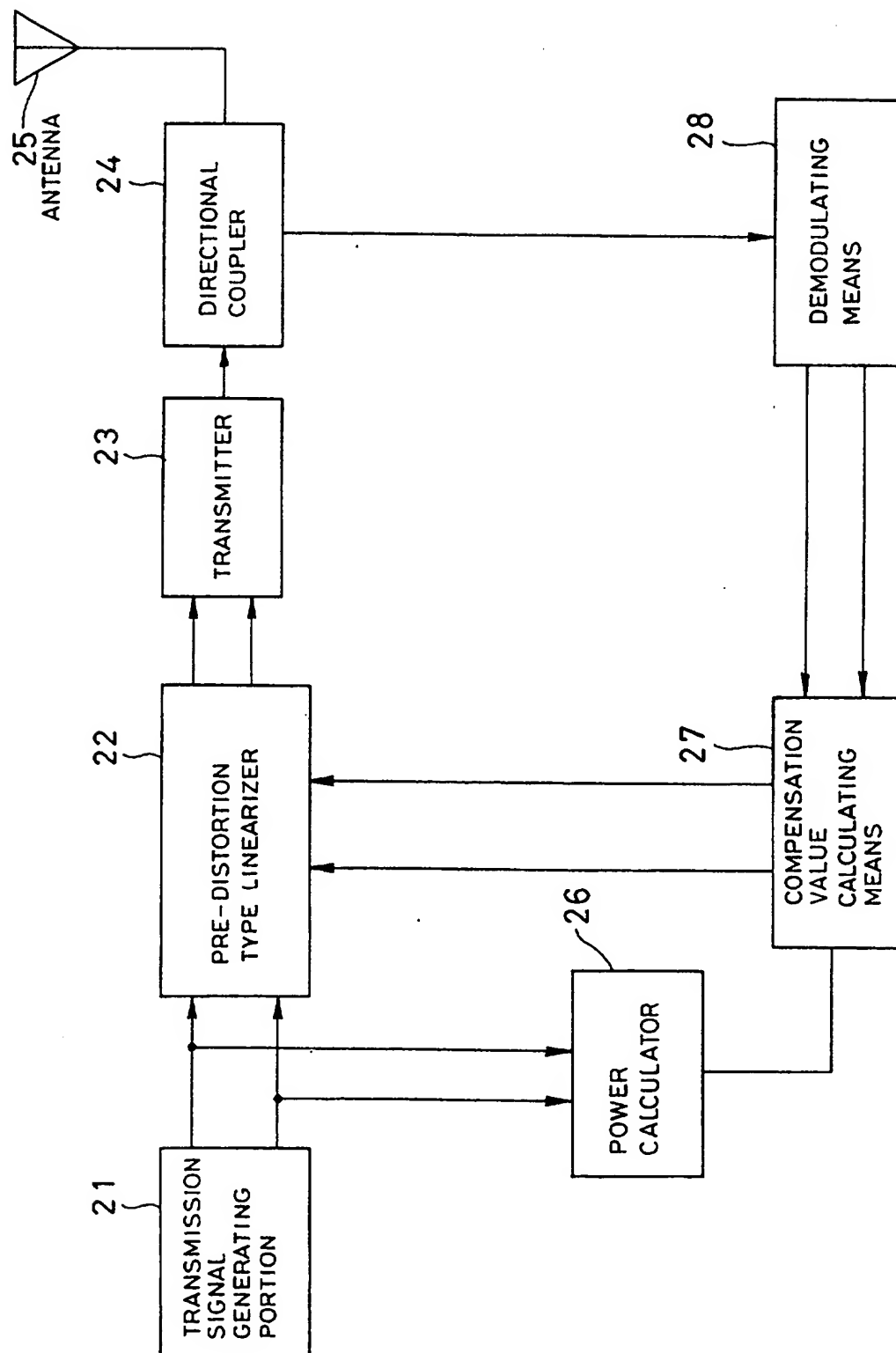


FIG. 7



TRANSMITTER AND DISTORTION COMPENSATION METHOD

TO BE USED THEREFOR

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a transmitter and a distortion compensation method to be used therefor. More particularly, the invention relates to a distortion compensating method in a transmitter having a pre-distortion
10 type linearizer.

Description of the Related Art

Conventionally, the transmitter of this type is constructed with a transmission signal generating portion 21, a pre-distortion type linearizer 22, a transmitter 23, a
15 directional coupler 24, an antenna 25, a power calculator 26, a compensation value calculating means 27 and a demodulation means 28, as shown in Fig. 7.

Here, since a transmission signal is distorted due to non-linear characteristics or an amplifier or the like, in case
20 of the transmitter 23 alone, the pre-distortion type linearizer 22 is provided between an output of the signal generating portion 21 and an input of the transmitter 23.

The pre-distortion type linearizer 22 performs correction for mutually canceling distortion component and
25 correction data component generated in the transmitter 23. By

this, distortion of an output waveform of the transmitter 23 can be improved. The directional coupler 24 divides an RF signal. Most of the power thereof becomes an output of the antenna 25. However, a part of the power is input to the
5 demodulating means 28. The power calculator 26 calculates an instantaneous power of a base band signal.

As a generation method of the compensation data input to the pre-distortion type linearizer 22, there is a method to return a part of the output of the transmitter 23 to the
10 base band signal by the demodulator 28 and to arithmetically derive the distortion component from this signal and the result of the power calculator 26 by the compensation value calculating means.

In the distortion compensation method in the conventional
15 transmitter set forth above, since the distortion component is arithmetically derived by returning a part of the transmitter to the base band signal by the demodulation means and calculating the distortion component from this signal and the result of the power calculator by the compensation value
20 calculating means, a scale of the circuit becomes large to also increase current consumption.

SUMMARY OF THE INVENTION

According to the first aspect of the present invention,
a transmitter assembly including a pre-distortion type
5 linearizer correcting to mutually cancel a distortion
component caused in a transmission signal and a correction data
component, comprises:

first storage means for preliminarily storing the
correction data.

10 According to the second aspect of the present invention,
a distortion compensation method for a transmitter including
a pre-distortion type linearizer correcting to mutually cancel
a distortion component caused in a transmission signal and a
correction data component, comprises steps of:

15 reading out a value corresponding to a transmission level
from a first storage means preliminarily storing the correction
data; and

inputting the read out value to the pre-distortion type
linearizer.

20 The first storage means may manage correction data as
table per transmission level. The transmitter assembly may
further comprise second storage means having a plurality of
table of the correction data per transmission frequency and
environmental temperature and means for updating storage
25 content of the first storage means with the corresponding table

of the second storage means when at least one of the transmission frequency and the environmental temperature is varied.

An address corresponding to the transmission level and a correction data corresponding to the address may be stored
5 in the first storage means. The transmission level may be a sum of an alternating current voltage value corresponding to an instantaneous power of a transmission signal and a direct current voltage corresponding to a part of the power of transmission output signal. The correction data may be
10 consisted of a predetermined amplitude value and a predetermined phase value of the transmission signal. The address corresponding to the transmission level and the correction data corresponding to the address may be stored in the first storage means.

15 Namely, the distortion compensation circuit for the transmitter assembly according to the present invention having the pre-distortion type linearizer stores the distortion compensation data to be transmitted to the distortion type linearizer in the first memory to sequentially update the data
20 in the first memory with the corresponding table in the second memory depending upon variation of the transmission frequency and the environmental temperature . By this, the transmitter with good transmission waveform can be realized with restricting power consumption without causing increasing of
25 circuit size.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinafter and from the accompanying drawings of the preferred embodiment of the present invention, which, however, should not be taken to be
5 limitative to the invention, but are for explanation and understanding only.

In the drawings:

Fig. 1 is a block diagram showing a construction of one
10 embodiment of a transmitter according to the present invention;

Fig. 2 is an illustration showing a correspondence between $V = (V_1 + v_2)$ and a generated address in an address generating portion of Fig. 1;

Fig. 3 is an illustration showing a correspondence
15 between an address and a compensation data in a first memory;

Fig. 4 is an illustration showing a correspondence between a temperature and a frequency and a compensation table in a second memory of Fig. 1;

Fig. 5 is an illustration showing a gain and a phase
20 characteristics of the transmitter alone of Fig. 1;

Fig. 6 is a flowchart showing a process operation of CPU of Fig. 1; and

Fig. 7 is a block diagram showing a construction of the conventional transmitter.

The present invention will be discussed hereinafter in detail in terms of the preferred embodiment of the present invention with reference to the accompanying drawings. In the following description, numerous specific details are set forth
5 in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structure are not shown in detail in order to avoid unnecessary
10 obscurity of the present invention.

Fig. 1 is a block diagram showing a construction of one embodiment of a transmitter according to the present invention. In Fig. 1, one embodiment of a transmitter assembly according to the present invention is constructed with a transmission
15 signal generating portion 1, a pre-distortion type linearizer 2, a transmitter 3, a directional coupler 4, an antenna 5, a power calculator 6, a first memory 7, a second memory 8, a CPU 9, an address generating portion 10 and a power detector portion 11.

20 The transmission signal generating portion 1 generates a base band signal of an I signal and a Q signal. The transmitter 3 modulates and amplifies the base band signal into an RF signal. Here, the transmission signal may cause distortion due to non-linear characteristics of the amplifier or so forth by the
25 transmitter 3 alone. Therefore, the pre-distortion type

linearizer 2 is provided between an output of a the transmission signal generating portion 1 and an input of the transmitter 3.

The pre-distortion type linearizer 2 makes correction for canceling distortion component generated by the transmitter 3 and a correction data component by multiplying a correction data provided from the first memory 7 and the base band signal with each other. By this, an output waveform of the transmitter 3 is improved distortion.

The directional coupler 4 divides the RF signal. Most of the power divided by the directional coupler 4 becomes an output of the antenna, and a part thereof is input to the power detector portion 11. The power detector portion 11 detects the RF signal and outputs a transmission level to the address generating portion 10 as a direct current voltage value V_1 . The power calculator 6 calculates an instantaneous power of the base band signal to output to the address generating portion 10 as a certain alternating voltage value v_2 .

The address generating portion 10 determines an address of data to be output by the first memory 7 from the direct current voltage value V_1 and the alternating current voltage value v_2 . The first memory 7 holds a compensation data in a form of a table for outputting the data contained in the designated address to the pre-distortion type linearizer 2.

A compensation data table of the first memory 7 is only

established under the same temperature and the same frequency for the transmitter 3. Therefore, it becomes necessary to update the compensation data table depending upon variation of an environmental temperature and a transmission frequency.

5 In the second memory 8, the compensation data tables are stored for all cases with taking the transmission frequency and the environmental temperature. CPU 9 transfers the compensation data table from the second memory 8 to the first memory 7 depending upon variation of the environmental temperature and
10 the transmission frequency.

Fig. 2 is an illustration showing a correspondence between $V = (V_1 + v_2)$ and the generated address in the address generating portion 10 of Fig. 1. In Fig. 2, there is illustrated the compensation data table storing addresses with
15 correspondence to the level of $(V_1 + v_2)$.

In the shown compensation table, "0" is stored as an address to be output when the level of $(V_1 + v_2)$ is " $< A_0$ ", "1" is stored as an address to be output when the level of $(V_1 + v_2)$ is " $A_0 \leq V < A_1$ ", "2" is stored as an address to be output
20 when the level of $(V_1 + v_2)$ is " $A_1 \leq V < A_2$ ", and "3" is stored as an address to be output when the level of $(V_1 + v_2)$ is " $A_2 \leq V < A_3$ ", ..., respectively.

Fig. 3 is an illustration showing a correspondence between the address and the compensation data in the first

memory 7 of Fig. 1. In Fig. 3, there is shown an example, in which the compensation data table #1 storing the address and the compensation data with correspondence is stored in the first memory 7.

5 In the compensation data table #1, a compensation data "- ΔG_{10} , - $\Delta \theta_{10}$ " is stored in an address "0", a compensation data "- ΔG_{11} , - $\Delta \theta_{11}$ " is stored in an address "1", a compensation data "- ΔG_{12} , - $\Delta \theta_{12}$ " is stored in an address "2", a compensation data "- ΔG_{13} , - $\Delta \theta_{13}$ " is stored in an address "3", ...,
10 respectively.

Fig. 4 is an illustration showing a correspondence between the temperature and frequency and the compensation data table in the second memory 8 of Fig. 1. In Fig. 4, there is shown an example, in which the compensation data tables "table
15 #0", "table #1", "table #2", "table #3" are respectively stored with correspondence with a temperature t ($t < t_0$, $t_0 \leq t < t_1$, $t_1 \leq t < t_2$, $t_2 \leq t < t_3 \dots$) and a frequency f (f_0, f_1, f_2, \dots).

Fig. 5 is an illustration showing a gain and a phase characteristics of the transmitter 3 alone of Fig. 1. Fig. 6
20 is a flowchart showing a process operation of CPU 9 of Fig. 1. Referring to Figs. 1 to 6, discussion will be given for operation of one embodiment of a distortion compensation circuit of the transmitter according to the present invention.

For example, considering the case that the transmission

frequency is f_0 and the temperature is t_1 to t_2 , a content of the compensation data table #2 corresponding to this condition is stored in the first memory 7. The base band signal generated by the transmission signal generating portion 1 is modulated
5 into the RF signal and amplified by the transmitter 3 via the pre-distortion type linearizer 2.

It is assumed that distortion of ΔG in amplitude of the transmission signal and $\Delta \theta$ in phase is caused in comparison with the ideal case where no internal distortion is present
10 in the transmitter 3 (see Fig. 5). The RF signal output by the transmitter 3 is divided by the directional coupler 4 to input a part of the divided power to the power detector portion 11.

The power detector portion 11 detects this signal to output the result of detection to an address generating portion
15 10 as the direct current voltage value V_1 . The address generating portion 10 combines the direct current voltage value V_1 and an instantaneous power value v_2 derived by the power calculator 6 to determine an address of the data to be output by the first memory 7 from $V_1 + v_2$. In Fig. 2, assuming, for
20 example, $A_1 \leq V_1 + v_2 < A_2$, the address becomes "2". Therefore, in Fig. 3, the first memory 7 outputs data $(-\Delta G_{12}, -\Delta \theta_{12})$ of the address "2" to the pre-distortion type linearizer 2.

Here, it is assumed that the temperature is varied from t_2 to t_3 . In Fig. 4, CPU 9 transfers the content of the

compensation data table #3 corresponding to this condition from the second memory 8 to the first memory 7 to update the data content of the first memory 7. For example, data of the address "2" of the first memory 7 becomes $(-\Delta G_{22}, -\Delta \theta_{22})$ taking the
5 temperature characteristics of the transmitter 3 into account.

Namely, when the transmission frequency is varied (step S1 of Fig. 6) or when the environmental temperature is varied (step S2 of Fig. 6), CPU 9 updates storage content of the first memory 7 corresponding to variation content of the compensation
10 data table in the second memory 8 (step S3 of Fig. 6).

Once updating of CPU 9 is completed, CPU 9 effects control for transmitting a value of the compensation data table in the first memory 7 corresponding to the address transmitted to the first memory 7 from the address generating portion 10 to the
15 pre-distortion type linearizer 2 (step S4 of Fig. 6).

When the transmission frequency or the environmental temperature does not vary, CPU 9 effects control for transmitting a value of the compensation data table in the first memory 7 before updating corresponding to the address
20 transmitted to the first memory 7 from the address generating portion 10 to the pre-distortion type linearizer 2 (step S4 of Fig. 6).

As set forth above, by storing the distortion correction data to be transmitted to the pre-distortion type linearizer
25 in the first memory 7 and sequentially updating data in the

first memory 7 with the storage content of the second memory
8 depending upon variation of the transmission frequency and
the environmental temperature, the transmitter assembly with
good transmission waveform can be realized without causing
5 increasing of circuit size and power consumption.

As set forth above, according to the present system,
in the transmitter assembly including the pre-distortion type
linearizer which effects correction for mutually canceling the
distortion component caused in the transmission signal and the
10 correction data component, by inputting the value
corresponding to the transmission level from the first memory
means preliminarily storing the correction data to the
pre-distortion type linearizer, current consumption can be
restricted without causing increasing of circuit scale.

15 Although the present invention has been illustrated and
described with respect to exemplary embodiment thereof, it
should be understood by those skilled in the art that the
foregoing and various other changes, omission and additions
may be made therein and thereto, without departing from the
20 scope of the present invention.

Therefore, the
present invention should not be understood as limited to the
specific embodiment set out above but to include all possible
embodiments which can be embodied within a scope encompassed
and equivalent thereof with respect to the feature set out in
25 the appended claims.

CLAIMS

1. A transmitter assembly including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component, comprising:

first storage means for preliminarily storing said correction data.

2. A transmitter assembly as set forth in claim 1, wherein said first storage means manages correction data as table per transmission level.

3. A transmitter assembly as set forth in claim 1, which further comprises:

second storage means having a plurality of table of said correction data per transmission frequency and environmental temperature; and

means for updating storage content of said first storage means with the corresponding table of said second storage means when at least one of the transmission frequency and the environmental temperature is varied.

4. A transmitter assembly as set forth in claim 2, wherein an address corresponding to said transmission level and a correction data corresponding to said address are stored in said first storage means.

5. A transmitter assembly as set forth in claim 2, wherein said transmission level is a sum of an alternating current voltage value corresponding to an instantaneous power of a transmission signal and a direct current voltage corresponding to a part of the power of transmission output signal.

6. A transmitter assembly as set forth in claim 1, wherein said correction data is consisted of a predetermined amplitude value and a predetermined phase value of the transmission signal.

5 7. A distortion compensation method for a transmitter including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component, comprising the steps of:

10 reading out a value corresponding to a transmission level from a first storage means preliminarily storing said correction data; and

inputting the read out value to said pre-distortion type linearizer.

15 8. A distortion compensation method as set forth in claim 7, wherein said first storage means manages the correction data in a form of table per transmission level.

9. A distortion compensation method as set forth in claim 7, wherein a storage content of said first storage means is
20 updated with a corresponding table in said second storage means storing a plurality of tables storing said correction data per transmission frequency and environmental temperature when at least one of said transmission frequency and environmental temperature.

25 10. A distortion compensation method as set forth in claim 8, wherein the address corresponding to the transmission level and the correction data corresponding to said address are stored in said first storage means.

11. A distortion compensation method as set forth in claim 8, wherein said transmission level is a sum of an alternating current voltage value corresponding to an instantaneous power of a transmission signal and a direct
5 current voltage corresponding to a part of the power of transmission output signal.

12. A distortion compensating method as set forth in claim 7, wherein said correction data is consisted of a predetermined amplitude value and a predetermined phase
10 value of the transmission signal.

13. A transmitter assembly including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component comprising:

15 transmission signal generating means generating a base band signal of an I signal and a Q signal; and

transmission means modulating and amplifying said base band signal into an RF signal; and

20 said pre-distortion type linearizer being provided between an output of said transmission signal generating means and an input of said transmission means; and

directional coupling means dividing RF signal; and

25 power detecting means detecting said RF signal and outputting a transmission level to address generating means; and

power calculating means calculating an instantaneous Power calculating of said base band signal to output to said address generating means; and

30 said address generating means detecting an address of data to be output by the first storage means from said transmission level and said instantaneous power of said base band signal; and

said first storage means for preliminarily storing said correcting data.

14. A transmitter assembly as set forth in claim 13, wherein said first storage means manages correction data as
5 table per transmission level.

15. A transmitter assembly as set forth in claim 13, which further comprises:

second storage means having a plurality of table of said correction data per transmission frequency and
10 environmental temperature; and

means for updating storage content of said first storage means with the corresponding table of said second storage means when at least one of the transmission frequency and the environmental temperature is varied.

15 16. A transmitter assembly as set forth in claim 14, wherein an address corresponding to said transmission level and a correction data corresponding to said address are stored in said first storage means.

17. A transmitter assembly as set forth in claim 14,
20 wherein said transmission level is a sum of an alternating current voltage value corresponding to an instantaneous power of a transmission signal and a direct current voltage corresponding to a part of the power of transmission output signal.

25 18. A transmitter assembly as set forth in claim 13, wherein said correction data is consisted of a predetermined amplitude value and a predetermined phase value of the transmission signal.

19. A distortion compensation method for a transmitter including a pre-distortion type linearizer correcting to mutually cancel a distortion component caused in a transmission signal and a correction data component, comprising the steps of:

providing said pre-distortion type linearizer between an output of said transmission signal generating means and an input of said transmission means; and

dividing RF signal by directional coupling means; and

detecting said RF signal and outputting a transmission level to address generating means by power detecting means; and

calculating an instantaneous power of said base band signal to output to said address generating means by power calculating means; and

determining an address of data to be output by the first storage means from said transmission level and said instantaneous power of said base band signal by said address generating means;

reading out a value corresponding to a transmission level from said first storage means preliminarily storing said correction data; and

inputting the read out value to said pre-distortion type linearizer.

20. A distortion compensation method as set forth in claim 19, wherein said first storage means manages the correction data in a form of table per transmission level.

21. A distortion compensation method as set forth in claim 19, wherein a storage content of said first storage means is updated with a corresponding table in said second storage means storing a plurality of tables storing said correction data per transmission frequency and environmental

temperature when at least one of said transmission frequency and environmental temperature.

22. A distortion compensation method as set forth in claim 20, wherein the address corresponding to the transmission level and the correction data corresponding to said address
5 are stored in said first storage means.

23. A distortion compensation method as set forth in claim 20, wherein said transmission level is a sum of an alternating current voltage value corresponding to an
10 instantaneous power of a transmission signal and a direct current voltage corresponding to a part of the power of transmission output signal.

24. A distortion compensation method as set forth in claim 19, wherein said correction data is consisted of a
15 predetermined amplitude value and a predetermined phase value of the transmission signal.

25. A transmitter assembly substantially as herein described with reference to Figs. 1 - 6 of the drawings.

26. A distortion compensation method substantially as
20 herein described with reference to Figs. 1 - 6 of the drawings.



INVESTOR IN PEOPLE

Application No: GB 0025038.1
Claims searched: 1-26

Examiner: Owen Wheeler
Date of search: 12 June 2001

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H3W (WULPR) H4P (PRE)

Int Cl (Ed.7): H03F: 1/32; H04B: 3/14, 7/005; H04L: 25/03, 25/49, 27/36

Other: Online: EPODOC, JAPIO. WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,P	GB 2337169 A	[NOKIA] See Fig. 1 and page 7 to page 9.	1,2,4,6-8,10,12
X	WO 99/17440 A1	[WHITAKER CORPORATION] See Figs. 3 and 5 and page 6 line 34 to page 10 line 28.	1,2,4,6-8,10,12
X	WO 98/51005 A1	[GLENAYRE ELECTRONICS] See in particular Fig. 15 and page 27 line 31 to page 29 line 29.	1,2,4,6-8,10,12
X	WO 98/12800 A1	[SPECTRIAN] See Fig. 1 and page 9 line 28 to page 12 line 4.	1,2,4,6-8,10,12
X	US 5524285 A	[WRAY] See Fig. 1 and column 3 line 4 to column 4 line 53.	1-4,6-10,12
X	US 5404378 A	[KIMURA] See Fig. 1 and column 1 line 49 to column 2 line 22.	1,2,4,6-8,10,12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.